

# Accelerator Test Facility for Muon Collider and Neutrino Factory R&D

*Vladimir Shiltsev/Fermilab*

AHIPA, Oct 20 ,2009

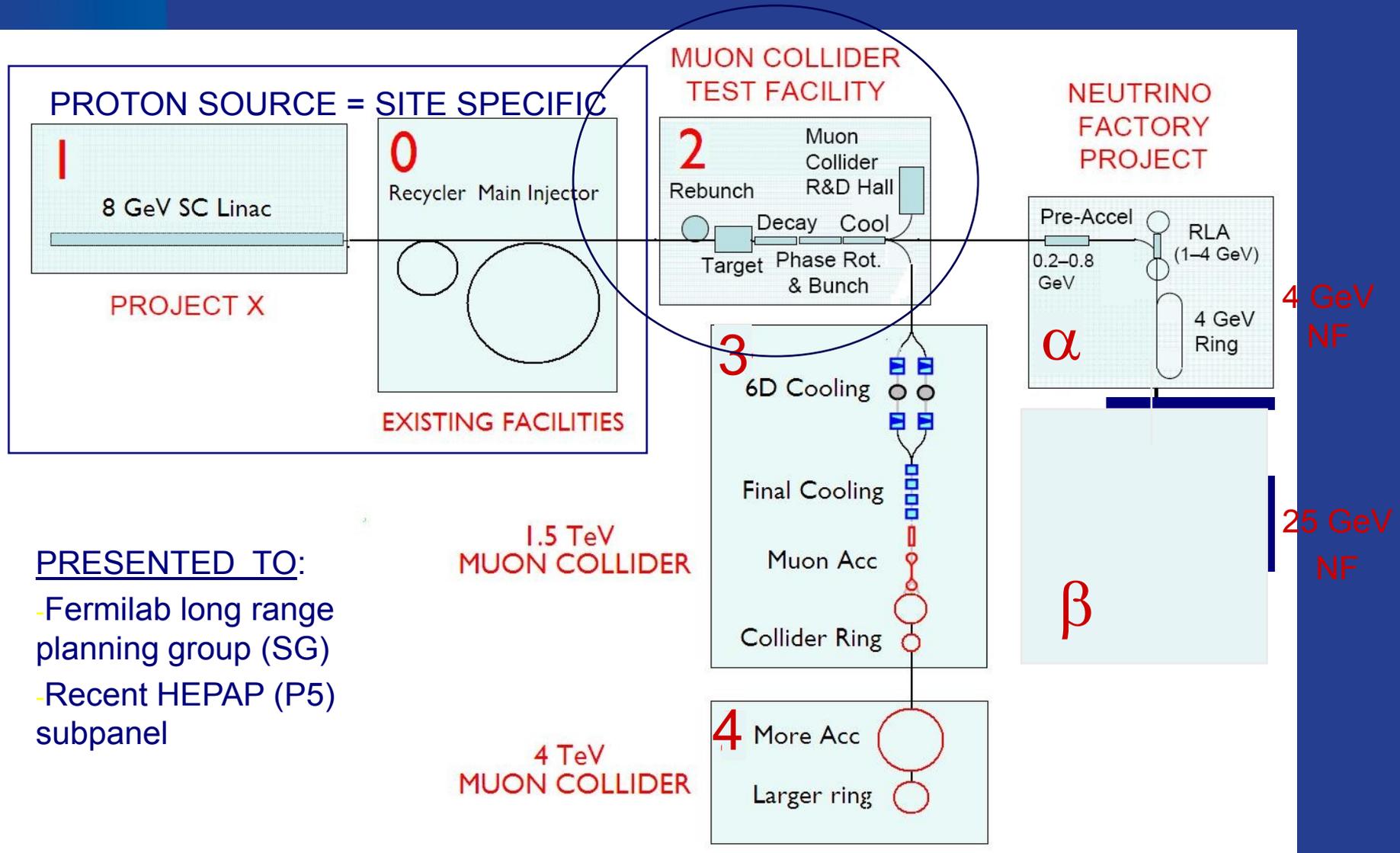
Fermilab

*with input from:*

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D.Neuffer, H.White, M.Syphers

# Muon Complex Evolution: P5 Vision



PRESENTED TO:

- Fermilab long range planning group (SG)
- Recent HEPAP (P5) subpanel

# Bigger Picture and Need of Facilities

- Main steps, milestones and \$\$ (view of optimist):
  - Now (Dec'09) – DOE Review of Nat'l MAP proposal
    - Decision to support 5 year plan
  - 5 year plan 2010-2014 (8-10M\$ → 16-20M\$/yr)
    - MC Feasibility Study Report, MICE, IDS-NF, 6D section
    - decision to proceed with the next 5 year plan
  - Next 5-years 2015-2019 (~30M\$ → 40-60M\$/yr)
    - CDR (TDR?) work, 6-D cooling section beam test
    - start of construction of Pr-X based Muon Test Facility
  - 2019-2024 (60M\$ → 100M\$/yr)
    - MTF demo of frontend+ long 6-D cooling channel, TDR
    - Decision to build MC

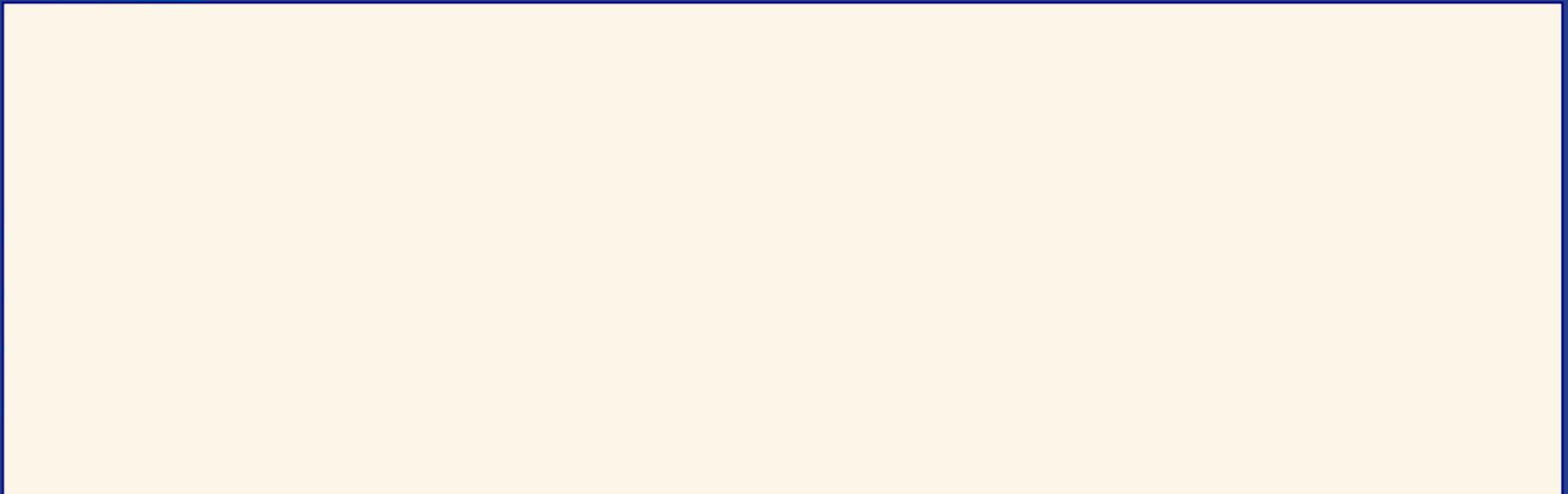
# Facilities Needed : Now and Then

- MTA (now – 2014+)

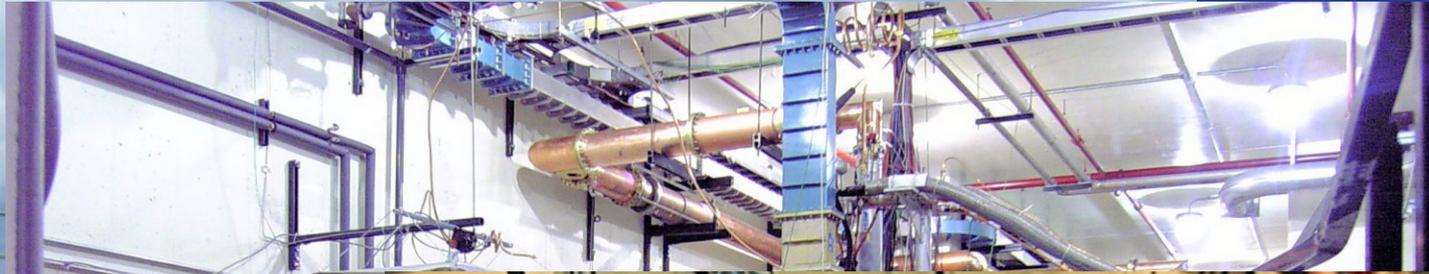
- Tests of components, RF studies

- MICE (now – 2014)

- Demo of 4D cooling, wedge tests



# MuCool Test Area



- cryogenic ca
- RF power at  $\lambda$
- Liquid  $H_2$  abs
- 5 T SC Solen
- (805 MHz Ca
- 400MeV/c pr

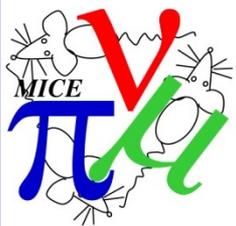
# Transverse (4D) Ionization Cooling

to be demonstrated by 2011 at RAL

Muon  
Ionization  
Cooling  
Experiment

ISIS accelerator

MICE experimental hall



# Muon Ionization Cooling Experiment

Final PID:  
TOF  
Cherenkov  
Calorimeter

## Status:

First beam,  $\mu$ 's : 2008

Funded in: UK,CH,JP,NL,US

4T spectrometer II

## Challenges:

201MHz RF in 3T field  
0.1% meas. of emittance  
LH2 safety issues

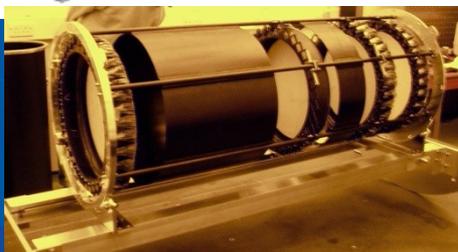
Cooling cell (~10%)  
 $\beta=5-45$  cm, liquid  $H_2$ , RF

4 T spectrometer I

TOF

Single- $\mu$  beam  
 $\sim 200$  MeV/c

Some  
prototyping:



Scintillating-fiber tracker



MUCOOL Liquid-hydrogen absorber



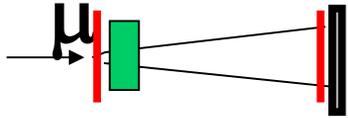
MUCOOL 201 MHz RF cavity with beryllium windows



# MICE Hal as of Mar'09

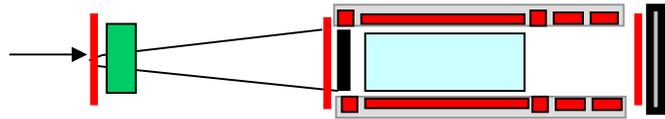


**Provisional MICE Schedule as of MUTAC 2009**  
 (NB cost and schedule under review for F.A.C. on 24 Apr09)



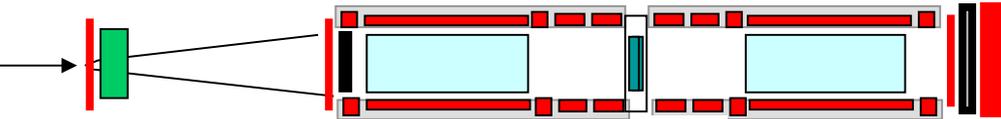
**STEP I**

fix DS + new target  
 Run: Sep09



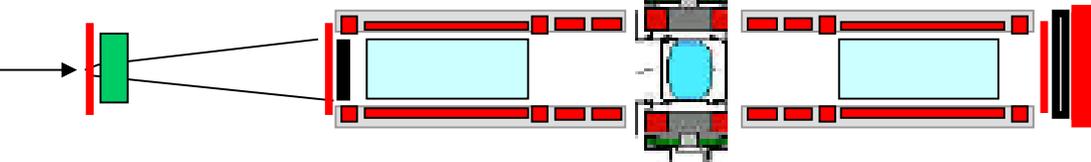
**STEP II**

Deliv SS-1 Jun09  
 Run: Q4 2009



**STEP III/III.1**

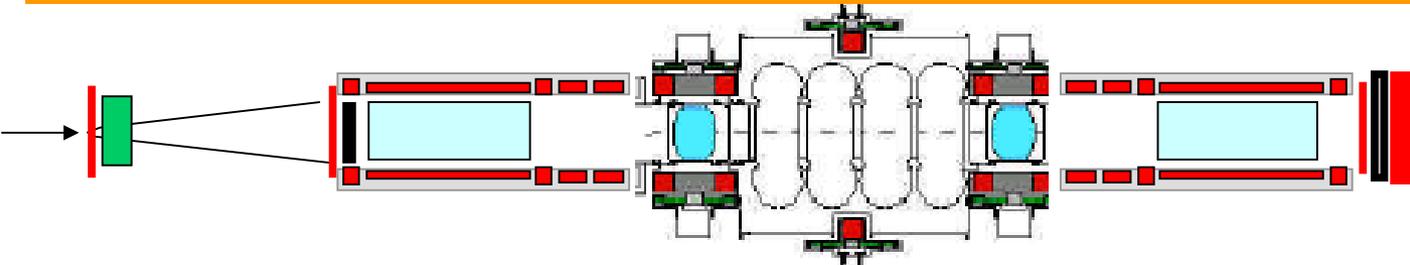
Deliv SS-2 Sep09  
 Run: Q1 2010



**STEP IV**

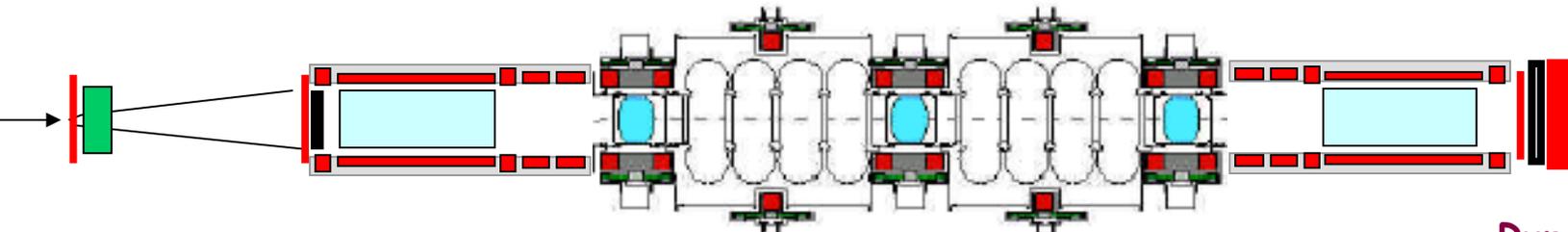
Deliv FC-1 Feb10  
 Run: Q2 2010

----- ISIS shut-down (provisional) Aug 2010 - Apr 2011 -----



**STEP V**

Run: 2011



**STEP VI**

Run 2011-2012

# Requirements for the New Facility



- **Appropriate timeline:**

- available sometime after 2012
  - when 6D cooling technology proven
- low intensity beam experiments till ~2018
  - demo of 6D cooling, get prepared for Pr-X beam
- upgrade/expand to take med-high intensity Project-X beam and do R&D till ~2024
- operation as MC or NF Front End >2025

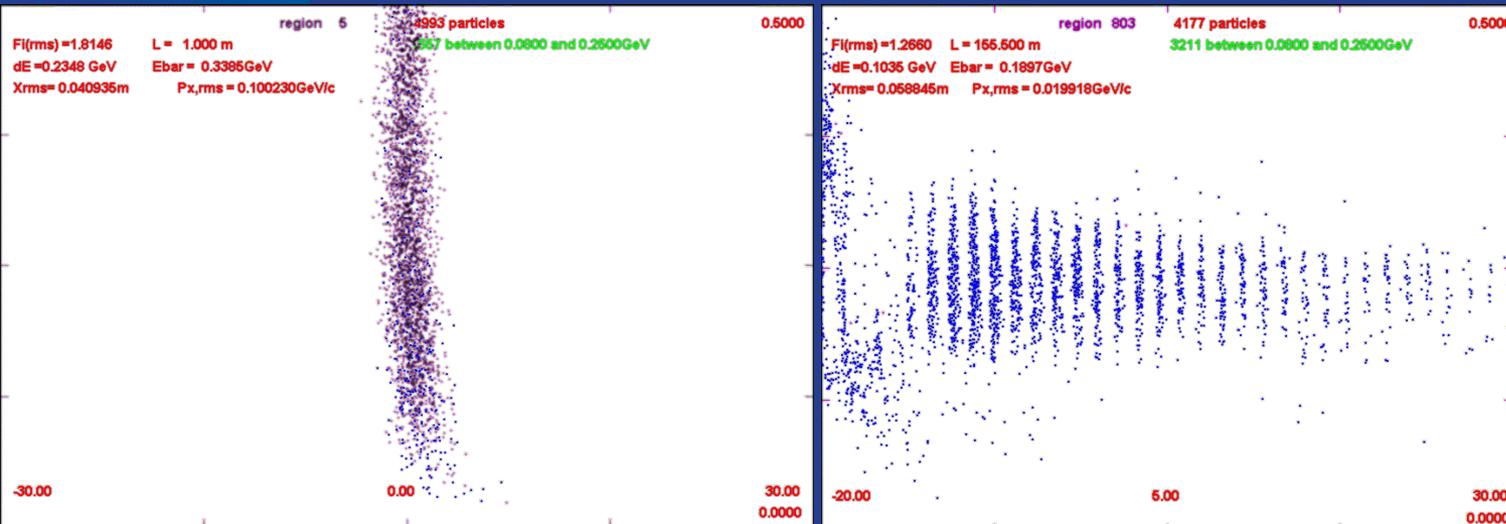
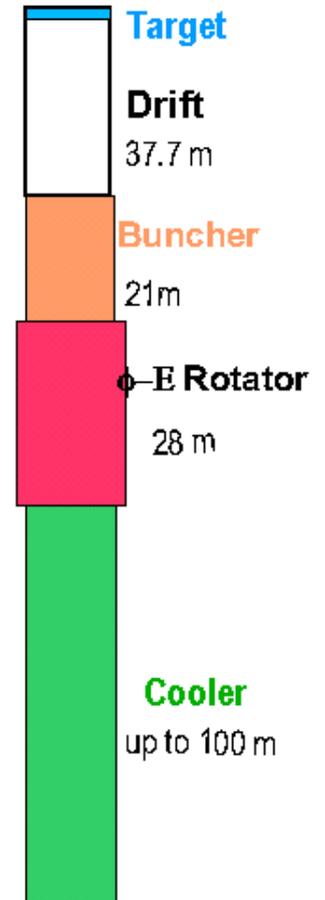
- **Technical:**

- i) space; ii) beam parameters; iii) cost

# Scale of The MC/NF Front-End

- See D.Neuffer et al

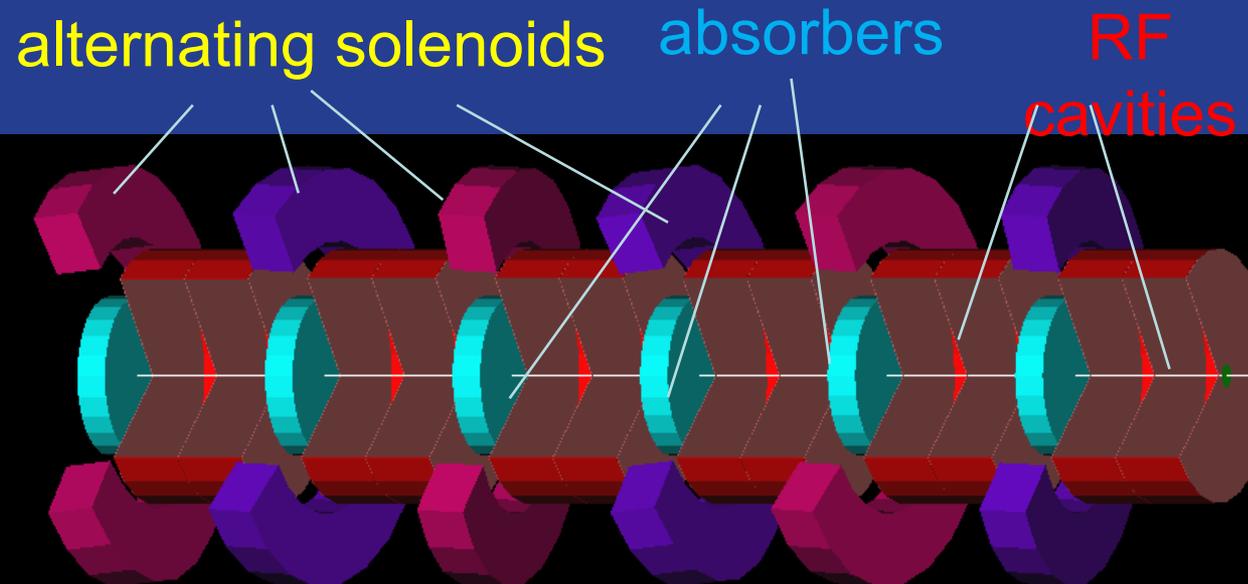
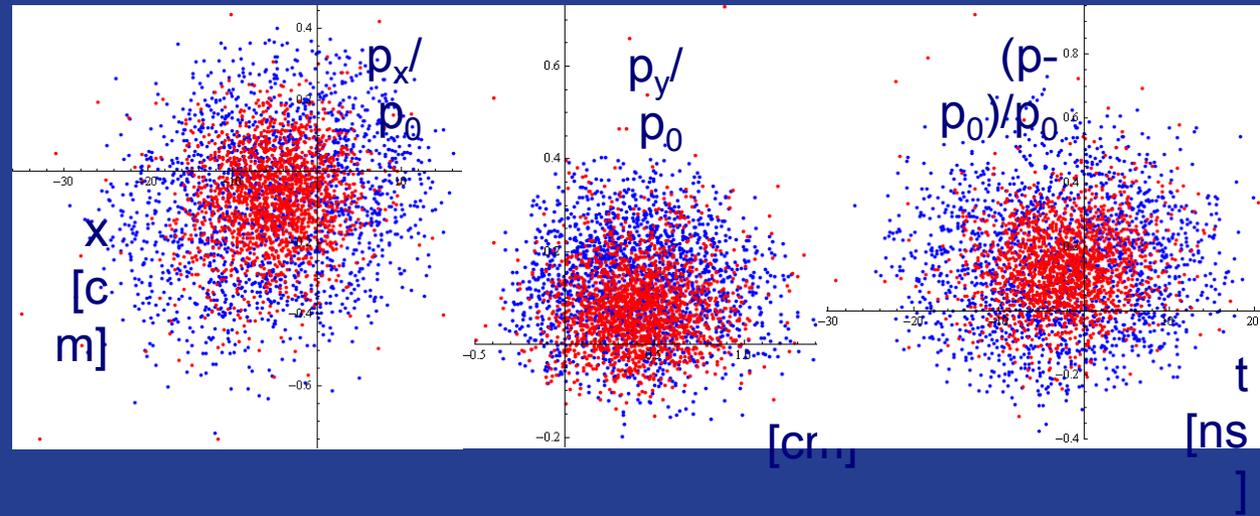
- Latest scheme: about 100 m for target+drift+buncher+rotator
- About 200 m for the previous-to-last scheme



# Scale of The 6DICE Channel

• See, e.g.,  
Yu. Alexahin  
et al

- 20-fold 6D emittance after 120 m
- 60 m  $\rightarrow$  x5 or  $\sim 1.7$  per plane



# Possibilities for the New Facility

- MICE
- MTA Hall
  - When 6D cooling technology proven
- Synergy with mu2e
  - Demo of 6D cooling
  - Get prepared for Project-X beam
- KTeV Hall
  - Be able to get med intensity beam

# MICE Hall

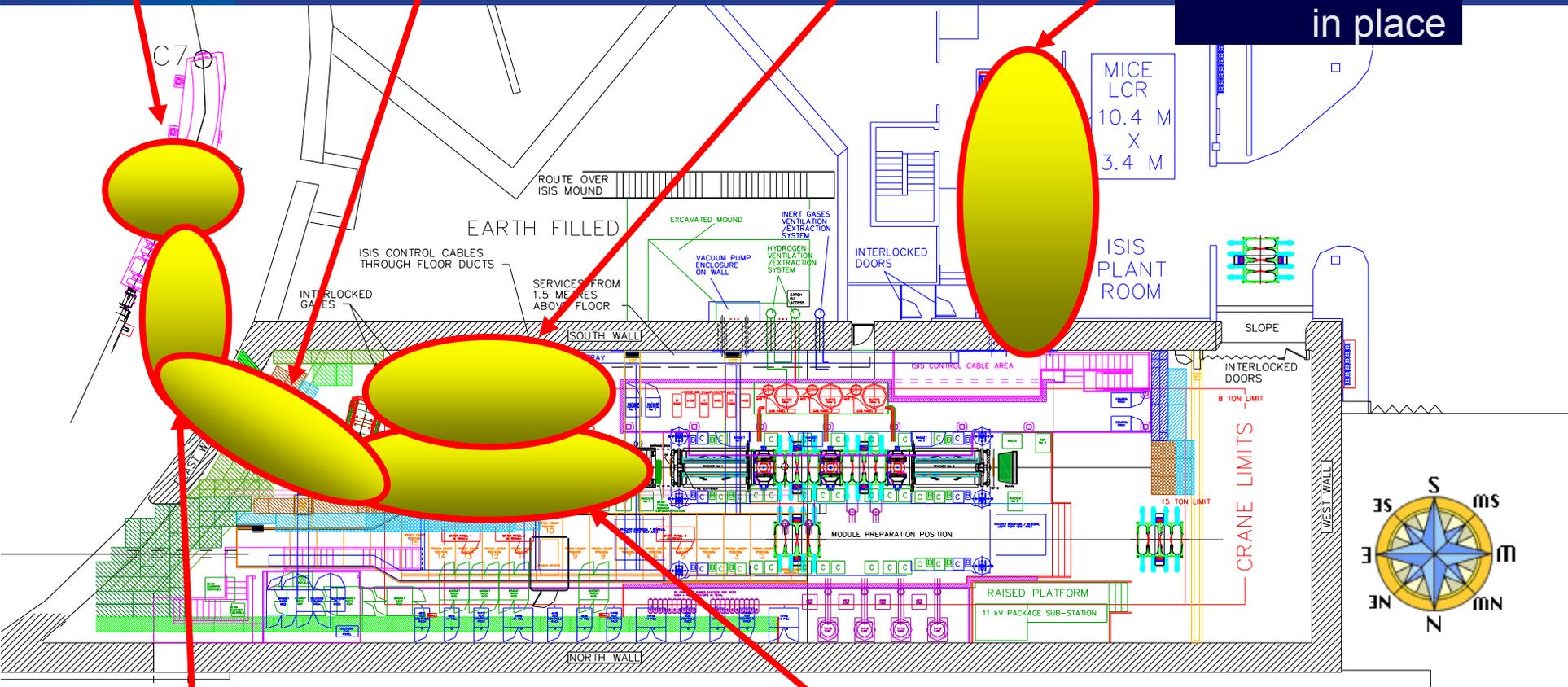
- Space very limited
- ISIS is not right source

Linde refrigerator:  
in place

MICE Local  
Control Room:  
in place

Target

Decay solenoid



Upstream  
Beamline:  
in place

Downstream beamline: in place

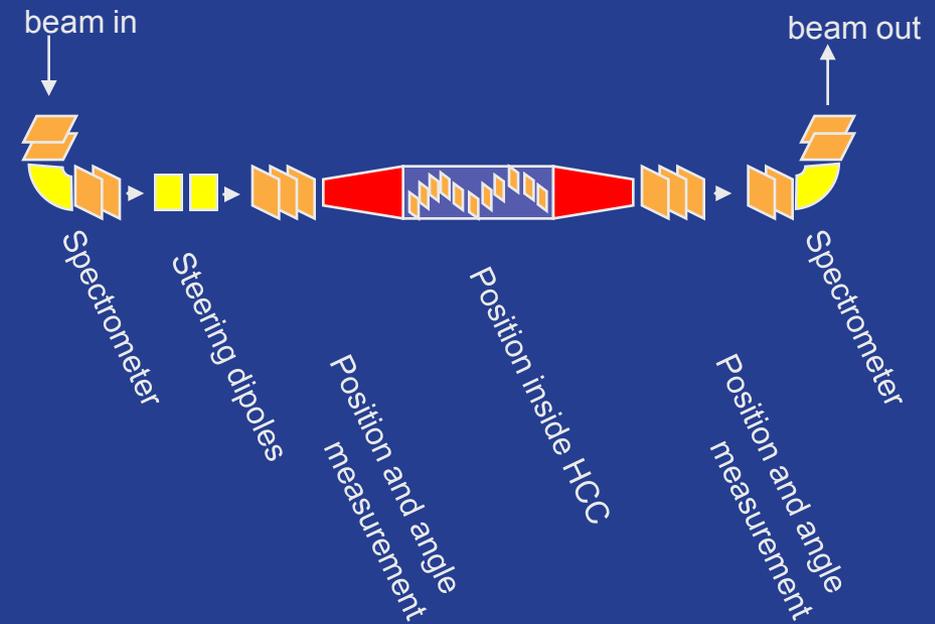
Instrumentation in place:

Beam monitors  
Trigger/rate scintillators  
CKov, TOF0&1, KL

# Beam Cooling Experiment in MTA Hall

- some  $1e-6$  muon per 400MeV/c proton
- huge proton flux
- hall is small
- will interfere with RF tests

Beamlet-type experiment  
-considered by A.Jansson  
in 2007

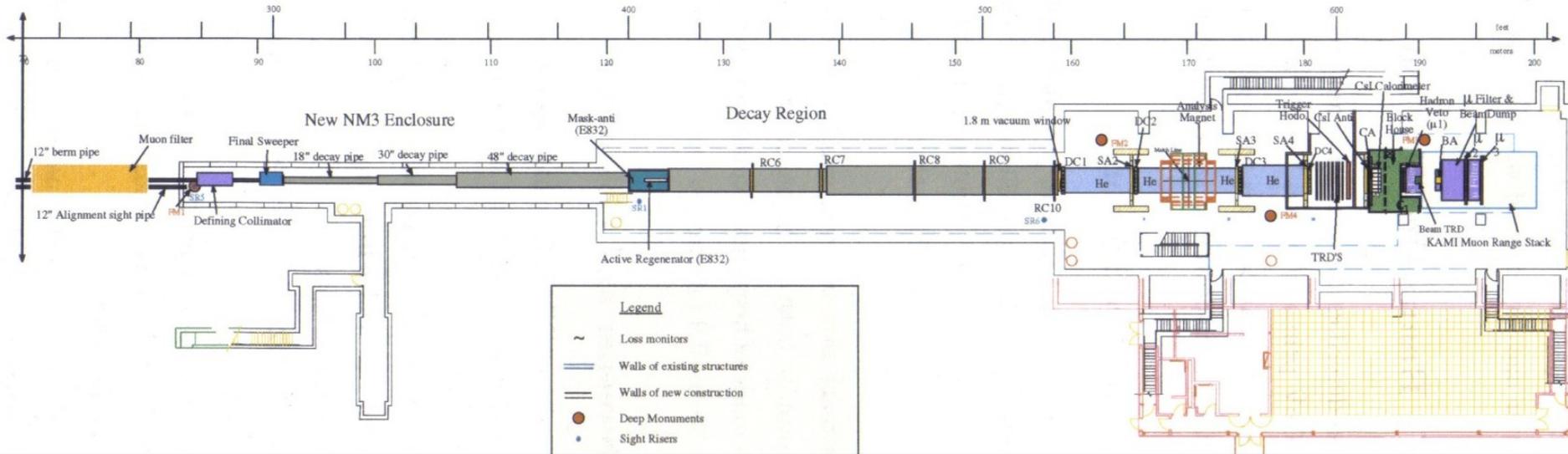




# KTeV Hall and Target Area



# KTeV Hall



- Three areas: 35m x 4x3m; 40 m x7x6 m; 45m x17x12m
- Control room and PS areas; 25-ton crane, water, lot of power available

# Availability

# Draft

Calendar Year	2010	2011	2012	2013	
Tevatron Collider	CDF & DZero	CDF & DZero	OPEN	OPEN	
Neutrino Program	B	MiniBooNE	MiniBooNE	OPEN	
		OPEN	OPEN	MicroBooNE	
	MI	MINOS	MINOS		OPEN
		MINERvA	MINERvA		MINERvA
		ArgoNeuT			
				NOvA	NOvA
SY 120	MT	Test Beam		Test Beam	
	MC	OPEN	OPEN	OPEN	
	NM4	E-906/Drell-Yan	E-906/Drell-Yan	E-906/Drell-Yan	

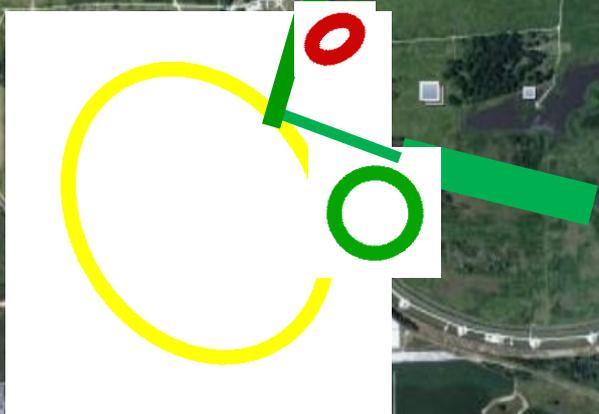
# Upgrade/Transition Strategy

- Start with 120 GeV beam from MI
- Build 8 GeV beam line (MI → KTeV hall)
- Get Pr-X 8 GeV beam at low rep rate
- Build buncher ring (8 GeV)
- Build Muon R&D/Front-end test facility
- Transform it to full blown MC or NF front end



Woodland Hills

... then proceed with MC or NF



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# Summary

- **Project-X will provide unprecedented flux of protons**
  - Even before upgrades – at 8 GeV
  - Even more after upgrades (TBD)
- **The needs of Muon Accelerator R&D call for reliable source of muons and facility to carry out tests of:**
  - Low-medium 6D Ioniz cooling experiment
  - Front-end facility
  - Full intensity research
- **KTeV Hall looks as a promising possibility**
  - Fully available after 2012m, spacious, target ares, power, water, etc
  - Has only 120 GeV beam line → will need 8 GeV at Stage II
  - Can be extended to full blown Front-End Area
  -

Some

# BACKUP SLIDES

# Muon Collider Parameters

CM Energy	1.5	4	TeV
<b>Luminosity</b>	<b>1</b>	<b>4</b>	<b><math>10^{34} \text{ cm}^{-2}\text{s}^{-1}</math></b>
Muons/bunch	2	2	$10^{12}$
Ring circumf.	3	8.1	km
Beta at IP $\beta^* = \sigma_z$	10	3	mm
dp/p (rms)	0.1	0.12	%
Ring depth*	13	135	m
PD Rep rate	12	6	Hz
<b>PD Power</b>	<b><math>\approx 4</math></b>	<b><math>\approx 2</math></b>	<b>MW</b>
<b>Transv.emm. <math>\epsilon_T</math></b>	<b>25</b>	<b>25</b>	<b><math>\pi \text{ mm mrad}</math></b>
Long. emm. $\epsilon_L$	72,000	72,000	$\pi \text{ mm mrad}$

\* *depth for  $\nu$  radiation keeps off site dose <1 mrem/yr*

# Muon Collider Scheme

